# Feature Extraction for Analysis of Electron Microscopy Images

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Transmission electron microscopy (TEM) provides extremely detailed high-resolution images of biological structures ranging from subcellular organelles to whole tissues. An advantage of this approach is that TEM allows simultaneous visualization of many different cellular components, providing a holistic view of a cell or tissue, in contrast to fluorescence microscopy which provides spatial information about only a few different types of cellular components in any one experiment.

However, the wealth of information in such images makes it diffult to extract particular details from many images at once. The most common type of information desired from electron microscopy images is quantitative morphology of cellular components, such as the number, shape, and distribution of particular organelles within a cell or the number and topology of connections between a group of cells.

A further challenge of electron microscopy data analysis is that in order to see whole cells at the fine resolution afforded by TEM requires tiling from many smaller images which must be computationally stitched together to create a larger image (which is then of considerable size). A final challenge of TEM is registering different slices of a cell to create a 3D reconstruction of a cell at high resolution. Due to the number of different processing steps required to create a complete EM reconstruction of a cellular volume, automated or semi-automated algorithms for feature extraction, image stitching, and tomography are crucial for efficient electron microscopy analysis.

Useful semi-automated tools are available for stitching together images and creating 3D tomograms Cardona et al. [2012], but this software is very general and hence requires significant manual input for any particular task, and furthermore does not provide many tools for sophisticated detection of relevant features in EM images. For the dedicated electron microscopist there is instead a need for more specialized tools optimized to streamline analysis of specific types of images, in particular the detection of particular features of interest.

## 1 Specific proposal

I propose to develop such a tool to specifically automate the process of imaging of a particular type of cell: a skin cell from fish (Fig. 1), which has a very dense meshwork of protein

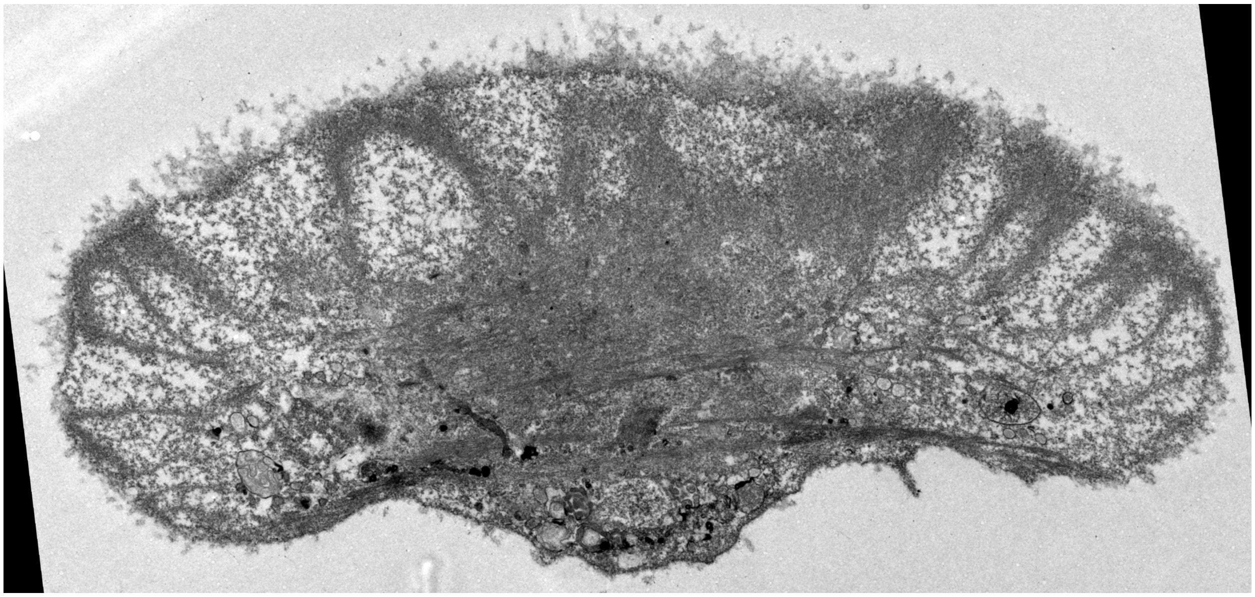

Figure 1: Electron micrograph of a fish skin cell. There are many different textures in this image representing different cellular features. I propose to develop an algorithm to distinguish some particular textures of interest.

filaments called the actin cytoskeleton that is of particular fascination to biologists interested in how cells move or transduce mechanical forces from their environment.

I will develop an image processing algorithm that will specifically detect this dense meshwork in a series of EM images and segment out this feature. I will then be able to feed this data into existing algorithms to create 3D reconstructions of the location of this meshwork feature for high-resolution analysis of cellular structure. This algorithm would be highly relevant to my research.

## 2 Techniques and Approaches

I expect that successfully identifying my features of interest will require a combination of different processing approaches. One approach will be to exploit the dark intensity of this area to try simple smoothing followed by thresholding of the image. However, there are many other dark regions in the image and I expect I will find many false positives.

To improve this approach, I will also try implementing feature detection strategies that rely on texture analysis, looking for more consistent or repetitive textures in images. One technique that has been successfully used on EM images of viruses is the local co-occurrence matrix of gray levels Proença et al. [2013], which looks for spatial correlations in the grayscale intensities of an image. Another technique that I will try is the use of Gabor filters, which are sensitive to orientational information and may be able to detect certain types of textures in these images well Gorai et al. [2014].

**I will NOT be using Android devices for my project.**

# References

Albert Cardona, Stephan Saalfeld, Johannes Schindelin, Ignacio Arganda-Carreras, Stephan Preibisch, Mark Longair, Pavel Tomancak, Volker Hartenstein, and Rodney J. Douglas. TrakEM2 Software for Neural Circuit Reconstruction. *PLoS ONE*, 7(6):e38011, 2012. ISSN 1932-6203. doi: 10.1371/journal.pone.0038011. URL `http://dx.plos.org/10.1371/journal.pone.0038011`.

Apurba Gorai, Kendrick Cetina, and Luis Baumela. A comparative study of local binary pattern descriptors and Gabor filter for electron microscopy image segmentation. *International Conference on Parallel, Distributed, and Grid Computing*, pages 76–81, 2014.

Maria C Proença, José F M Nunes, and António P A de Matos. Texture indicators for segmentation of polyomavirus particles in transmission electron microscopy images. *Microscopy and microanalysis*, 19(5):1170–82, 2013. ISSN 1435-8115. doi: 10.1017/S1431927613001736. URL `http://www.ncbi.nlm.nih.gov/pubmed/23773502`.